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VIII. *Obſervations and Conjectures on the Earthquakes of* New-England. *By Profeſſor* WILLIAMS, *F. A. A.*

IN looking over ſome of the hiſtories of *New-England*, I obſerved, that the religious turn of mind which diſtinguiſhed the firſt planters of *New-England*, had lead them to take notice of all the Earthquakes which happened in the country, after their arrival. Several of them ſeemed to be pretty well deſcribed; and in ſome of their phenomena, there ſeemed to be an agreement. As ſeveral of theſe accounts were contained in writings but little known, I thought it might be of ſome ſervice to philoſophy, if a particular account of them could be collected. This is what I have attempted in the following treatiſe. In the *firſt part* of it, I have ſet down the moſt particular accounts I could find of their phenomena. The *ſecond* contains obſervations and remarks upon their agreement and operations. In the *third*, conjectures are propoſed as to their cauſes: and in the *fourth*, ſome general reflections are added as to their nature, uſe, and effects.

The moſt likely way to come to the knowledge of their cauſes, is to obſerve all the phenomena that attend them. That the reader might have a true account of theſe phenomena, it was my endeavour, in the accounts and obſervations, to note all the particulars that ſeemed to relate to them, however minute or trivial ſome of them might appear. With this view, I conſulted all the accounts I could find. From ſeveral of them, (the Honourable Profeſſor *Winthrop's* Lectures on Earthquakes, in particular) I have received much help. Others referred to authors of which I could not have the advantage of a peruſal. That gentlemen of ſcience might have it in their power to examine with what fidelity and care the accounts are drawn up; or how far they might be depended upon, I have conſtantly referred to the authors from which they are taken. Some of the accounts, I am ſenſible, are greatly imperfect: as all our conjectures, theories, and reaſonings, muſt depend on the accounts, it is much to be wiſhed, that ſomething more accurate and perfect, as to ſeveral of them, might be tranſmitted down to poſterity.

What is propoſed as to their *cauſes*, will be judged of, by the degree of probability and evidence with which it is attended. In all philoſophical hypotheſes, a writer is in danger of making more of his ſubject than will bear a ſtrict examination. I have found ſome difficulty in guarding againſt this: and whether, at laſt, I have not carried *conjectures*, in ſome things, too far, the reader muſt judge for himſelf. After all, the revolutions of time will afford the ſureſt proof of the truth or errors contained in the following pages. I would, therefore, make it my requeſt to poſterity, to note, with care and accuracy, the phenomena that may attend any future earthquakes in *New-England*; that, if what is here advanced as to their cauſes, ſhall be found to be true, it may be confirmed; but, if found to be falſe, it may meet with the fate of other errors, and be rejected. The cauſe of truth and ſcience, is of infinitely more importance, than any of our ſchemes or conjectures: and this is what I wiſh may prevail, in all countries, and in all ages.

An HISTORICAL ACCOUNT of the EARTHQUAKES of NEW-ENGLAND.

THE *Engliſh* arrived at *Plimouth*, in *New-England*, November 11, 1628. The *firſt* earthquake that happened in the country after their arrival, was on July 2, 1638, O. S. The *manner* of its approach, and the *violence* to which it aroſe, are pretty well deſcribed in accounts which are yet exiſting. It is deſcribed as having been preceded with a rumbling noiſe, or low murmur, like remote thunder. As the noiſe approached, the earth began to quake, till the ſhock aroſe to ſuch a violence, as to throw down the pewter from the ſhelves, ſtone walls, and the tops of ſeveral chimnies ; and, in ſome places, made it difficult for people to avoid falling. The *courſe* of this earthquake, in ſome of the accounts, is deſcribed as being from the weſtward to the eaſtward. In others, it is repreſented as coming from the northward, and going off ſouthward. It is not likely any great care, or accuracy, was employed, to determine what particular point of the compaſs the roar or ſhake came from ; but only to fix it to that, which was judged to be the neareſt cardinal point, which ſome thought was the weſt, others the north. It is moſt probable, therefore, that a middle courſe, from about north-weſt to ſouth-eaſt, was the true ; as this will beſt agree with, and reconcile all the other accounts that were given of its courſe. To what *extent* this earthquake reached, on any point of the compaſs, we have no way to determine.— It is ſaid in general, that it reached far into the land, and was obſerved by the *Indians* much beyond any of the *Engliſh* ſettlements, which then were but of ſmall extent. And alſo, that ſome veſſels, which were near the coaſt, were ſhaken by it.

In about half an hour there was another ſhock, but not ſo long or ſtrong as the former.*

Omitting a ſhock on October 29, 1653, as too ſmall to occaſion a general notice, the next memorable earthquake, was in 1658. In all the ancient hiſtories, this is mentioned as a *great* earthquake. But I cannot find any account of the month, day, violence, courſe, effects, extent, or any other particulars of it.

On January 26, 1663, O. S. "at the ſhutting in of the evening,"† another memorable earthquake ſhook *New-England*. From the general expreſſions the writers who ſpeak of it uſe, it ſeems to have been one of the *greateſt* this country ever felt. It is repreſented as being preceded with a great noiſe and roar. Mention is made of the houſes rocking, the pewter falling from the ſhelves, the tops of ſeveral chimnies falling in, the inhabitants running out into the ſtreets, paſſengers being unable to keep on their feet, &c. As to its *courſe*, *duration*, or *extent*, nothing is to be found in any of the *New-England* writers. But they are well deſcribed in the accounts that were given of this earthquake in *Canada*.

At the ſame time, February 5, 1663, N. S. "about half an hour after five in the evening," a moſt terrible earthquake began there. The heavens being very ſerene, there was ſuddenly heard a roar, like that of a great fire. Immediately the buildings were ſhaken with amazing violence. The doors opened and ſhut of themſelves, with a fearful clattering. The bells rang, without being touched. The walls ſplit aſunder. The floors ſeparated, and fell down. The fields put on the appearance of precipices,

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* Vide *Johnſon's*, *Hubbard's*, and *Morton's* accounts of this earthquake.

† *Morton*.

precipices; and the mountains ſeemed to be moving out of their places: and amidſt the univerſal craſh which took place, moſt kinds of animals ſent forth fearful cries and howlings.

The *duration* of this earthquake was very uncommon. The firſt ſhock continued half an hour before it was over; but it began to abate in about a quarter of an hour after it firſt began. The ſame day, about eight o'clock in the evening, there was a ſecond ſhock, equally violent as the firſt; and in the ſpace of half and hour, there were two others. The next day, about three hours from the morning, there was a violent ſhock, which laſted a long time: and the next night, ſome counted thirty-two ſhocks; of which, many were violent.—Nor did theſe earthquakes ceaſe until the July following.

New-England and *New-York* were ſhaken with no leſs violence than the *French* country. And, throughout an *extent* of three hundred leagues from eaſt to weſt, and more than one hundred and fifty from north to ſouth, the earth, the rivers, and the banks of the ſea, were ſhaken with the ſame violence. The ſhocks ſometimes came on ſuddenly; at other times by degrees. Some ſeemed to be directed upwards; others were attended with an undulatory motion.—And throughout the vaſt extent of country to which they reached, they ſeemed to reſemble the motions of an intermitting pulſe, with irregular returns; and which commenced through the whole at the ſame hour.

This earthquake was attended with ſome remarkable *effects*. Many fountains and ſmall rivers were dried up. In others, the water became ſulphureous: and in ſome, the channel in which they ran before, was ſo altered that it could not be diſtinguiſhed. Many trees were torn up, and thrown to a conſiderable diſtance.

And ſome mountains appeared to be much broken and moved. Half way between *Tadouſſac* and *Quebec*, two mountains were ſhaken down: and the earth thus thrown down, formed a point of land, which extended half a quarter of a league into the river *St. Lawrence*. The iſland *Aux Coudres*, became larger than it was before: and the channel in the river, became much altered.*

From theſe accounts it is evident, that *Canada* was the chief ſeat of theſe concuſſions: and of conſequence, as it proceeded from thoſe parts, its *courſe* muſt have been from ſome point between the weſt and north; probably much the ſame with that of 1638.

After an interval of ſixty-four years, (in which there had been ſeveral ſmall ſhocks, but none ſo violent as to occaſion a very long remembrance†) there came on another very memorable one, October 29, 1727, O. S. About $10^{h.}$ 40, P. M. in a very clear air and ſerene ſky, when every thing ſeemed to be in a moſt perfect calm and tranquility, a heavy rumbling noiſe was heard. At firſt it ſeemed to be at a diſtance, but increaſed as it came near, till it was thought equal to the roar of a blazing chimney, and at laſt to the rattling of carriages, driving fiercely on pavements. In about half a minute from the time the report was firſt heard, the earthquake came on. It

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* Vide *Frezier's* Voyage, p. 210, 211. Journal des *Scavans Mai.* 1678. *Charlevoix's* Hiſtoire de la *Nouvelle France*.

† In Phil. Tranſ. No. 437, mention is made of earthquakes in 1660, 1665, 1668 and 1669. Dr. *Mather* ſpeaks of earthquakes in 1670 and in 1705. There was another in 1720, on January 8. But theſe, with ſome others, having been too ſmall to occaſion a general notice, and being only mentioned without any particular account of them, are paſſed by, as not affording us any light with regard to the nature, cauſe, or effects of theſe phenomena.

was obſerved by thoſe that were abroad, that as the ſhake paſſed under them, the ſurface of the earth ſenſibly roſe up, and then ſunk down again; which muſt have produced an *undulation* of the earth, or a motion like that of a wave, both perpendicular and horizontal; firſt riſing in a perpendicular direction, and as it ſubſided, ſpreading itſelf in a horizontal direction all around. The nature, therefore, or *kind* of the *motion*, was *undulatory.* The *violence* of the ſhock, like that of the other great earthquakes, was ſuch as to cauſe the houſes to ſhake and rock, as if they were falling to pieces. The doors, windows, and movables, made a fearful clattering. The pewter and china were thrown from their ſhelves. Stone walls, and the tops of ſeveral chimnies were ſhaken down. In ſome places, the doors were unlatched and burſt open, and people in great danger of falling, There were various opinions as to the *duration* of this earthquake. The moſt probable is, that the ſhake began about half a minute after the roar was firſt heard, and roſe to its greateſt height in about a minute more; and was about half a minute in going off. Whence, the *duration* may be ſuppoſed to have been about two minutes. It was very generally agreed, that the *courſe* of this earthquake was from north-weſt to ſouth-eaſt. "The noiſe and ſhakes, it is ſaid, ſeemed to come from the "north-weſtward, and to go off ſouth-eaſterly; and ſo the "houſes ſeemed to reel." This account of its courſe, was confirmed by all the others, one or two excepted, which differ ſo much from one another, that nothing can be determined from them. With regard to the *limits* of this earthquake, it extended from the river *Delaware*, in *Pennſylvania*, ſouth-weſt, to *Kennebeck*, north-eaſt. At both theſe places it was ſenſibly felt, though the ſhake was but ſmall. Its extent, therefore, from ſouth-weſt to north-eaſt, muſt at leaſt have been ſeven hundred miles, and probably many more. As to its other limit, from north-weſt to ſouth-eaſt, we have no way to determine how far it extended. It was felt by veſſels at ſea, and in the moſt remote weſterly ſettlements. As it came from the unknown parts, between the weſt and north, and paſſed off into the ſea, it is probable it might run ſome thouſand miles in ſuch a courſe.

There were ſeveral *effects* attending this earthquake, which ſeem worthy of remark. Beſides what is common, as to the throwing down pewter, fences, &c. it was obſerved, that ſeveral ſprings of water, and wells, that were never known to be dry or frozen, were ſunk far down into the earth. Some were dried up. The quality of the water mended in ſome, and ſo altered in others as to freeze in moderate weather. Some ſpots of firm dry ſoil, became perfect quagmires; and others, that were full of mire and water before, became more dry. The centre of this earthquake, or place of greateſt violence, ſeems to have been at *Newbury*, a town which lies at the mouth of *Merrimack-River*. "There, (according to Dr. *Colman's* account) "the earth opened, and threw up ſeveral loads of a fine "ſand and aſhes, mixt with ſome ſmall remains of ſulphur; "ſo that, taking up ſome of it between the fingers, and dropping it into a chaffing-diſh of bright coals, in a dark place, "once in three times the blue flame of the ſulphur would "plainly ariſe, and yield a very ſmall ſcent. By this it ſeems "evident, that it was a ſulphureous blaſt which burſt open the "ground, and threw up the calcined bituminous earth."* Concerning

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* Phil. Tranſ. No. 409. What is here ſaid of its being a ſulphureous blaſt, ſeems to be confirmed by the account which Mr. *Dudley* ſent to the Royal Society, in which

cerning this earth which was thrown up, the Rev. Mr. *Lowel*, miniſter in *Newbury*, mentions an uncommon circumſtance. "One thing (ſays he) I may add, which is very remarkable, "and which may be depended on: that about the middle of "April, that fine ſand, which was thrown up in ſeveral places "in this pariſh, at the firſt great ſhock, October 29, had a very "offenſive ſtench; nay, was more nauſeous than a putrifying "corps; yet, in a very little while after it had no ſmell at all. "How long it was before it begun to have this ſtench I am "not certain. I know it had it not at firſt: and, I believe, it "was covered with ſnow till a little while before.—There is no "ſmell now."* Theſe accounts refer to matters ſo eaſy to be known, that there is no room to ſuſpect that the authors (both gentlemen of a philoſophic taſte, as well as of eminence in their particular profeſſions) could be miſtaken. And it ſeems highly probable, from their obſervations, that the ſand which was thrown out by the earthquake, contained ſome very noxious, ill-ſcented vapour, or effluvia; which, ſo long as there was nothing to confine it, paſſed away in quantities too ſmall to be perceptible to the ſenſes: but when it was kept together by the ſnow, gathered in ſuch quantities as ſtrongly to infect the air, when the melting of the ſnow gave it liberty to evaporate freely.

Some

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which he ſays, "A clergyman in a town about twenty miles from *Boſton* aſſured "him, that immediately after the earthquake, there was ſuch a ſtink, or ſtrong "ſmell of ſulphur, that the family could ſcarce bear to be in the houſe for a conſiderable time that night. The like is alſo confirmed from other places. Perſons "of credit do alſo affirm, that juſt before, or in the time of the earthquake, they "perceived flaſhes of light." Phil. Tranſ. No. 437.

* Letter to Dr. *Colman*. Phil. Tranſ. No. 409.

Some *phenomena* were obſerved a few days before this earthquake, which deſerve our notice, as having, probably, ſome *connection* with its approach. The Rev. Mr. *Allin*, then miniſter of *Brooklyn*, took notice of an uncommon alteration in the water of ſome wells. "About three days (ſays he) before "the earthquake, there was perceived, an ill-ſtinking ſmell in "the water of ſeveral wells. Not thinking of the proper cauſe, "ſome ſearched their wells, but found nothing that might thus "infect them. The ſcent was ſo ſtrong and offenſive, that for "about eight or ten days they entirely omitted uſing it. In "the deepeſt of theſe wells, which was about thirty-ſix feet, "the water was turned to a brimſtone colour, but had nothing "of the ſmell; and was thick like *puddle-water*."§ We have this account confirmed by Mr. *Dudley*.—"A neighbour of his "that had a well thirty-ſix feet deep, about three days before "the earthquake, was ſurpriſed to find his water, that uſed to "be very ſweet and limpid, ſtink to that degree that they could "make no uſe of it, nor ſcarce bear the houſe when it was "brought in; and imagining that ſome carrion was got into "the well, he ſearched the bottom, but found it clear and good, "though the colour of the water was turned wheyiſh, or pale. "In about ſeven days after the earthquake, the water began to "mend; and in three days more, it returned to its former "ſweetneſs and colour."* And juſt before the earthquake began, ſeveral wells were found to have no water in them, which had great quantities before and after. To whatever cauſe the alterations in theſe wells be aſcribed, it can hardly be thought but that they had ſome *connection* with the earthquake, which in a few days ran through the whole country. Several ſhocks were felt in the northern parts of *New-England*, for ſome months after that of October 29: but they were generally ſmall and of a ſhort duration.*

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§ Account of the earthquake of 1727, by Mr. *Allin*.

* Phil. Tranſ. No. 437.

In 1732, there was an earthquake, which, though ſmall, was of a conſiderable extent. It came on September 5, O. S. at about 11$^{h.}$ A. M. being attended with a rumbling noiſe; and was of ſuch *violence* as to occaſion a conſiderable jarring of the houſes. The *duration* of it, was not more than ten or fifteen ſeconds. This earthquake was much more evident at *Montreal* in *Canada*, than it was in any part of *New-England*; being attended with conſiderable damage there. As this was the chief ſeat of it, it ſeems to have come from thence, in a *north-weſterly courſe*, to *New-England*. Its *extent*, from ſouth-weſt to north-eaſt, was equal to that of moſt of the earthquakes that have been in the country; being felt from *Maryland* to the *northeaſterly* parts of *New-England*: and from north-weſt to ſouth-eaſt, it reached from *Montreal*, and probably from many miles beyond it, to the ſea-coaſt.‖

From the year 1732, though there had been ſome ſmall ſhocks, there was none that occaſioned a general notice, till 1744. That year, on June 3, O. S. a fair and hot day, there was an earthquake, ſo conſiderable, as to be generally felt thro' the province. It began a few minutes after 10$^{h.}$ A. M. being preceded with a very loud report; and is ſaid to have roſe to ſuch a *violence*, as to ſhake down ſome bricks from the tops of ſome chimnies, and alſo ſome pieces of ſtone wall. The *courſe* of this earthquake is ſaid, by ſome that remember it, to have been from the *weſtward* to the *eaſtward*. As to other particulars I can find no account.[†]

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* The account of this earthquake is collected from the printed accounts of it in the Philoſophical Tranſactions, and by ſeveral of the *New-England* miniſters.

‖ Vide Phil. Tranſ. No. 429, and for 1757, p. 13, and alſo Profeſſor *Kalm's* travels, vol. i. p. 44, 2d edit. *London*. On February 6, 1737, at 4¼ P. M. and December 7, a little before eleven at night, ſmall earthquakes were felt at *Boſton*: but no particulars are mentioned as to their phenomena.

The next earthquake, that ſhook the whole country, was in the year 1755. November 18, N. S. at 4h. 11′ 35″,[‡] in a calm, ſerene and pleaſant night, came on the moſt violent ſhock of an earthquake that was ever known in *New-England*. The firſt thing obſervable, was that rumbling noiſe, or roar, which as a ſound *ſui generis*, ſeemed a prelude to an earthquake. In about half a minute, the ſurface of the earth ſeemed to be ſuddenly raiſed up; and, in ſubſiding, was thrown into a univerſal trembling, or a very quick, jarring, vibratory motion, which acted in an horizontal direction. This motion continued for about a quarter of a minute, and then abated for three or four ſeconds. Then, all at once, came on a violent, prodigious ſhock, as ſuddenly, to appearance, as a thunder-clap breaking upon a houſe, and attended with a great noiſe. This ſudden and great ſhock began with the ſame *kind* of motion; and was immediately ſucceeded by quick and violent concuſſions, jerks and wrenches, attended "with an undulatory, waving motion of the whole ſurface of the ground, not unlike the ſhaking and quaking of a very large bogg." After this great ſhock had been gradually declining and going off, near half a minute, there was a ſenſible revival of it, though of ſhort continuance; and ſo all by degrees became ſtill and quiet again.

[†] Phil. Tranſ. for 1757, p. 14, and *American* Mag. for 1744.

[‡] The beginning of this earthquake was determined to all the exactneſs that could be deſired, by the following accident.—Profeſſor *Winthrop* at *Cambridge*, ſome time before, having uſed a pretty long glaſs tube, in a particular experiment, ſhut it up in his clock-caſe, for ſecurity. This tube, ſtanding nearly perpendicular, muſt have been overſet by the firſt ſhock, which made it impoſſible for the pendulum to make any oſcillation, after the tube had ſtruck againſt it. The clock ſtopped at the time mentioned above. Being a very good one, and having been adjuſted by a meridian line, the preceding noon, it muſt have pointed out the beginning of the earthquake to a great preciſion. Had the time been as accurately determined at any other diſtant place, the velocity of its motion might have been determined to great exactneſs.

The *violence* of this earthquake was the greateſt of any we have ever had in the country. "In *Boſton*, beſides the throwing down of glaſs, pewter, and other movables in the houſes, about an hundred chimnies were, in a manner, levelled with the roofs of the houſes; and about fifteen hundred ſhattered, and thrown down in part. Some were broken off ſeveral feet below the top; and by the ſuddenneſs and violence of the jerks, canted horizontally an inch or two over, ſo as to ſtand very dangerouſly. Some others, thus broken off, were turned round ſeveral points of the compaſs, as with a circular motion. The roofs of ſome houſes were quite broken in by the fall of chimnies. The ends of about twelve or fifteen brick buildings were thrown down, from the top to the eaves of the houſes. Many clocks were ſtopped. The vane upon the public market-houſe was thrown down;—the wooden ſpindle, which ſupported it, being broken off at a place where it was five inches in diameter, and ten feet in height; and which had ſtood the moſt violent guſts of wind. A new vane, upon one of the churches in the town, was bent at the ſpindle, two or three points of the compaſs: and a diſtiller's ciſtern, made of plank, almoſt new, and very ſtrongly put together, was burſt to pieces, by the agitation of the liquour in it; which was thrown out with ſuch force, as to break down one whole ſide of the ſhed that defended the the ciſtern from the weather; as alſo to ſtave off a board or two from a fence, at the diſtance of eight or ten feet from it." Much the ſame things were obſerved in the country. At *Springfield*, a town diſtant about eighty miles in a weſterly line from *Boſton*, a ſpindle on one of their churches, was bent to a right-angle.—And through the whole province, much damage was done by the throwing down of ſtone fences, cellar walls, chimnies, and the like. Theſe things may ſerve to give us pretty juſt ideas of its *violence*: but it is to be obſerved, that the violence of the ſhock was different in different places; and not exactly the ſame in towns contiguous to one another; or indeed in all the parts of the ſame town.

There has been no earthquake in the country, whoſe *duration* was determined with ſo much accuracy as was that of this. Profeſſor *Winthrop* at *Cambridge*, the day before, had adjuſted his clock and watch by a meridian line. His clock was ſtopped at 4h. 11' 35". Being awaked by the earthquake, he aroſe, and looking upon his watch, found it to be fifteen minutes after four. The jarring continued about a minute after this. The next day the watch was found to have kept time very exactly. So that the *duration* of the earthquake, taking in the whole of the time from the firſt agitation of the earth, till it became perfectly quiet, was very nearly four and an half minutes; though the violence of the ſhock did not laſt half ſo long. This obſervation of its duration at *Cambridge*, agreed pretty well with ſome of the ſame kind made at *Boſton*, by gentlemen who were up, and looked upon their watches when it began and ended.

In

In other places, its duration might be different, according to the different violence of the ſhock.

By the accounts of thoſe who were in the commons and open places, when the earthquake began, the *courſe* of it was nearly from north-weſt to ſouth-eaſt. It was almoſt univerſally agreed, that the noiſe and ſhakes ſeemed to paſs in that direction: and thoſe things which were in ſuch a ſituation as that they might have been thrown indifferently to any point of the compaſs, pretty generally lay in that direction.

The *extent* of this earthquake, was traced to a great diſtance. On the ſouth-weſt, it reached as far as *Cheſapeake-Bay* in *Maryland*: being felt on the eaſtern, but not on the weſtern ſide. To the north-eaſt, it was felt as far as *Halifax*. It is much more difficult to determine its weſtern or eaſtern limit.—It extended to all our back ſettlements;—was felt at *Lake George*, and probably many miles beyond: but at *Oſwego*, ſituate on the ſouth-eaſtern ſhore of *Lake Ontario*, and diſtant from *Boſton* about two hundred and fifty miles weſt-by-north, it was not felt at all. On the *Atlantic*, the ſhock was ſo great ſeventy leagues eaſt of *Cape Ann*, that the people on board a veſſel, in that longitude, thought they had run aground, or ſtruck upon a rock, till on ſounding they found they had more than fifty fathom water. By accounts, which were ſoon after received from the *Weſt-Indies*, it ſeems probable that the earthquake reached as far as thoſe iſlands; or, rather, paſſed by to the eaſtward of them. The account was, " That on the 18th of November, " about two o'clock in the afternoon, the ſea withdrew from " the harbour of *St. Martin's*, leaving the veſſels dry, and fiſh " on the banks, where there uſed to be three or four fathom " water: and it continued out a conſiderable time; ſo that the

" people retired to the high lands, fearing the conſequence of " its return: and when it came in, it aroſe ſix feet higher than " uſual, ſo as to overflow the low lands. There was no ſhock " felt at the above time."

As this extraordinary motion of the ſea happened about nine hours after the great ſhock was felt in *New-England*, it ſeems very likely to have been occaſioned by the ſame convulſion of the earth. As this earthquake went off ſouth-eaſtward into the *Atlantic*, it would paſs conſiderably to the eaſtward of *St. Martin's*, which has about 18° of north latitude, with 62½° of weſt longitude. And this was the caſe at the iſland. There was no ſhock felt; but the motion of the ſea was probably owing to a great agitation, raiſed at a conſiderable diſtance, in ſome part of the ocean, by the paſſage, or by an eruption of the earthquake, and from thence propagated to that iſland.—And what ſeems to be a confirmation of this, the length of time was no greater than what ſeems neceſſary for ſuch a purpoſe. We cannot, indeed, ſtate, with great accuracy, the *velocity* with which the earthquake moved: but yet it is very evident from its duration, and being preceded with a roar, that its motion was not very ſwift: and that of the waves, raiſed hereby, and propagated to the land, muſt have been much ſlower: both of which might eaſily take up nine hours in being propagated, and that in a circular direction, to ſuch a diſtance as that of *Boſton* and *St Martin's*. The *extent*, therefore, of this earthquake, from ſouth-weſt to north-eaſt, muſt have been about eight hundred miles: but from north-weſt to ſouth-eaſt, it reached at leaſt nineteen hundred; and, perhaps, many more.

As the *effects* of this earthquake, great alterations were obſerved in the ſprings, wells and ponds of water. In ſome, the quality of the water was altered ; in others, the quantity. New ſprings were opened ; old ones dried up : the channel in many, was much changed ; and the water in ſome was obſerved to boil up in an unuſual manner, for ſeveral days both before and after the earthquake. At *Pembroke*, *Scituate* and *Lancaſter*, there were chaſms made in the earth. At *Pembroke*, there were four or five of them ; out of ſome of which, water iſſued, and many cart-loads of a fine, whitiſh and compreſſible ſort of ſand, was ſpewed.* Nor were its effects confined to the land ;—ſeveral of the ſea-faring men agreed in their accounts, that almoſt immediately after the earthquake, large numbers of fiſh, of different ſorts, both great and ſmall, came up to the ſurface of the water,—ſome dead, and others dying. One of the fiſhing veſſels, at that time out upon the *Banks*, took up and brought in ſeveral quintals of theſe fiſh, which were found in large numbers, dead and dying, upon the ſurface of the ſea.†

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* Speaking of this ſand, " By what I have heard," ſays Dr. *Mayhew*, " it was " of a ſulphureous nature." It is to be regretted, that no experiments were made with it, to determine, with certainty, whether this was the caſe or not.

† In phenomena, of whoſe cauſes we have ſo little knowledge, it is beſt to note every circumſtance however minute, and whether it ſeems to have much connection with the ſuppoſed cauſes or not ; as we do not know but that they may be of uſe, when future obſervations come to be compared with them. For this reaſon, it may not be amiſs to ſubjoin to the above account, 1. That at the time of the earthquake, there was no alteration in the atmoſphere, as to its weight or temperature : the *barometer* and *thermometer* not undergoing any alteration. 2. A very great white froſt was obſerved in the morning, much larger than had been for ſeveral years. When it was melted, Profeſſor *Winthrop* meaſured it, and found that it covered the ground.

There were ſeveral ſmall ſhocks ſoon after this of November 18.—One in about an hour and a quarter after the firſt, viz. at $5^{h.}$ $29'$. A ſecond, on November 22, at twenty-ſeven minutes after eight at night. A third, on December 19, at $10^{h.}$ P. M. Their *violence* and *duration* was ſmall ; their *courſe*, much like that of the great ſhock ; and their *extent*, ſuch as to be pretty generally felt through the country. Many others, but very ſmall, were felt in different parts of the *Maſſachuſetts* and *New-Hampſhire*, for ſeveral months after.

In 1757, there was another earthquake ; which, tho' ſmall, was generally felt. I cannot find any printed account of this ſhock, and, therefore, can only mention ſome general obſervations, which I then made of it. It came on July 8, N. S. at about $2^{h.}$ $20'$, P. M. I was then in an open field, ſurrounded with pretty high hills, from ſouth-weſt to north-eaſt, in company with another perſon. The firſt thing we perceived, was a ſmall noiſe, like that of a riſing wind, which ſeemed to be at a great diſtance, but ſwiftly advancing. It was half a minute before there was any ſhock. This I inferred, not barely from any conjecture I was then able to make, which in a ſtate of ſurpriſe muſt be greatly uncertain, but from this circumſtance : after hearing the noiſe, we had enquired of each other what it could be ; and as there was no ſhake, concluded it was not an earthquake, when immediately the ſhock came on. The converſation I well remember ; and am certain it muſt have taken up half a minute, if not more. The *ſhock* itſelf was not of very

great

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ground $\frac{17}{1000}$ parts of an inch ; which was almoſt double of any there had been for ſeven years before, and about five or ſix times as great as what is common in this country. The account of this earthquake is collected from Profeſſor *Winthrop's* Lecture, and account of it in Phil. Tranſ. for 1757, art. 1. and from Drs. *Chauncey's* and *Mayhew's* accounts of it.

great force; but ſeemed as though ſome ſmall body was ſwiftly rolling along under the earth, which gently raiſed up that part of the ſurface that was over it, and then left it as gently to ſubſide. The *courſe* of this earthquake appeared, to me, to be from the ſouth-weſt to the north-eaſt.—The noiſe and ſhake ſeemed very plainly to come on, and go off in that direction. I might, however, be deceived by the reflection of the ſound from the adjacent hills, or from ſome other cauſe; for almoſt every one judged very differently of its *courſe*, that it was from north-weſt to ſouth-eaſt. This was the judgment of ſeveral men, who were at work together, in a large open field, where there was nothing to reflect the ſound, or miſlead the judgment. It is not impoſſible that both might have been right in their opinion; and this, upon the whole, I am apt to think was the caſe: that although its general *courſe* was from north-weſt to ſouth-eaſt, yet, in particular places, it left its general courſe, and run out to any point of the compaſs, as the ſubterraneous veins, or channels, might lead it. From the effects of other earthquakes, particularly that of turning and twiſting chimnies, &c. it ſeems as though this had been the caſe with moſt of the large earthquakes we have had.

On the 12th of March, 1761, there was alſo a ſmall earthquake. It began about $2^{h.}\ 30'$ in the morning. It was ſaid to have been divided into two ſhocks, with a ſmall pauſe between, the laſt of which was the greateſt. The weather was moderate, like that of the preceding day, and a perfect calm reſted on the land and water; the horizon, all around, being covered with a whitiſh fog. The *duration* was ſuppoſed to be about half a minute. Happening in the night, and being too ſmall to awake people in general, nothing can be collected with any certainty as to its *courſe*. Its *extent*, however, was conſiderable; being felt not only in the *Maſſachuſetts*, but in moſt of the adjoining ſtates.

The ſame year, on November 1, about 8h. P. M. there was another earthquake. As uſual, this was preceded with a heavy rumbling noiſe, which increaſed to a pretty loud report as it came near. There was a conſiderable interval of time between the roar and the ſhake. I endeavoured to make ſome computation of it by this method: juſt as the ſhock began to abate, I looked on my watch to note the time. The report I could hear for about half a minute after this. It is probable it was about as long in coming on, which would give half a minute between the noiſe and ſhake. The *ſhock* itſelf was of the *undulatory* kind; not *violent*, but ſufficient to make the doors and windows jarr and clatter. Its *courſe* was very plainly from north-weſt to ſouth-eaſt, and it was pretty generally felt through the ſtate, and in *New-Hampſhire*.

In the years 1766, 1769, and 1771, there were ſmall earthquakes. Their *courſes* were all, I think, from about north-weſt to ſouth-eaſt. Their *durations* not more than twelve or fifteen ſeconds; and their *extent* but ſmall. Not being attendded with any thing remarkable, it is not neceſſary to write particular accounts of them.

November 29, 1783, about 10h. 54′, P. M. there was another ſmall earthquake in *New-England*. Its *extent* was very conſiderable; being felt in *Pennſylvania*, *New-Jerſey*, *New-York*, *Connecticut*, *Rhode-Iſland*, *Maſſachuſetts* and *New-Hampſhire*. At *Boſton*, there was but one ſhock; and that was not violent enough to be generally perceived. At *Hartford* and *New-Haven*, in *Connecticut*, but one ſhock was perceived; but it ſeems to have been more conſiderable than at *Boſton.* At *New-York,* three ſhocks were felt, about the hours of nine, eleven, and two the next morning. At *Philadelphia,* they had a ſhock about eleven o'clock, and another the next morning, about two. At the firſt of theſe, "moſt of the houſes were "very ſenſibly ſhaken," but the other was not generally felt. Being but ſmall in moſt places, and happening in the night, the *courſe* of this earthquake was not much attended to. The only remark I can find upon this, is in an account from *New-Haven;* in which it is ſaid, "Its *courſe* was nearly from north "to ſouth, and it continued about one minute."

OBSERVATIONS and REMARKS on the EARTHQUAKES of *NEW-ENGLAND.*

TO have a general view of the agreement and diſagreement of the phenomena that have attended the earthquakes of *New-England,* it may be of uſe to make ſome general obſervations on the preceding HISTORICAL ACCOUNT.

It ſeems worthy of remark, that all the earthquakes of this country, have been of the ſame *kind.* Writers on this ſubject, have ſometimes diſtinguiſhed earthquakes into two different kinds, according to the different *motions* of which they have conſiſted.—In ſome, an *horizontal,* in others, a *perpendicular* motion has been chiefly obſerved. In the one, the earth ſeemed to move, as it were, from ſide to ſide: in the other, its motion ſeemed to be up and down. Both theſe motions have been united in the earthquakes of *New-England.* All, of which we have had any particular account, have come on with an *undulatory* motion, like that of a wave; which firſt riſes till it comes to its greateſt height, and then ſubſides; and in ſubſiding, ſpreads itſelf, with an horizontal motion, all around. This has appeared, with the moſt ſenſible evidence, to be the caſe, in all the earthquakes I have ever felt. They have all appeared, to me, to come on, as if a ſolid body, or a wave of earth, (if the expreſſion may be allowed) was rolling along under the ſurface of the earth; which firſt raiſed that part which was over it, and then left it gradually to ſubſide: the conſequence of which was, a ſtrong *undulatory motion* of the earth; which was immediately ſucceeded with an univerſal trembling, or very quick, jarring, vibratory motion, as though the earth was ſtruggling to recover its former poſition.

Another thing obſervable in the earthquakes of *New-England* is, they have all gone in much the ſame *courſe*. As to two or three of the earthquakes, we have no account of their *courſe*: but in all thoſe in which it was determined, there is a very great agreement. They are all deſcribed as coming from about north-weſt, and going off about ſouth-eaſt. As this was the caſe with all whoſe direction was obſerved, we may rationally conclude, that they all proceeded in pretty much the ſame general track; in a path from about north-weſt to ſouth-eaſt, though with many ſmall deviations and irregularities, in particular places. This, if I do not miſtake, has not been generally the caſe in the earthquakes of other places. The great earthquakes which have ſpread deſolation in *Sicily*, *Peru*, and *Jamaica*, inſtead of proceeding in any regular courſe, are deſcribed rather as inſtantaneous blaſts, which ſtruck dreadfully upwards,—not proceeding in any certain tract, from one country to another; but ſuch as burſt and rent a large circle of earth all around. But with us, they have all proceeded in a different manner; and in a manner apparently regular;—fiercely driving along, as it were, in the ſame path, as though a paſſage had been opened for, or by them, from one country to another; in ſome places coming more near, and in others, running more remote from the ſurface of the earth. And the diſtance to which ſome, and probably ſeveral have run in the ſame courſe, has been greatly amazing;—nineteen hundred miles at leaſt, and how much more we know not.

From the laſt remark it ſeems probable, that the earthquakes of this country, have had their *origin* at ſome conſiderable diſtance to the north-weſt of *New-England*, and poſſibly at much the ſame place. Whatever might be the caſe with thoſe ſmall ſhocks that have had but a ſmall extent, or whereſoever they might begin, the larger ones have all been obſerved to come from the north-weſt; and they were of much the ſame violence at the moſt north-weſterly ſettlements, as at other places in the country. The place, therefore, where they have had their *origin*, muſt have been in ſome part of the unknown lands which lie to the north-weſt of *New-England*; and probably at ſome conſiderable diſtance from any of the *European* ſettlements; as there has been no account from any of them, in which it had not the ſame direction, coming on from the north-weſt. Whether the great ſhocks have all originated at the ſame place, we have no way to determine; but from the agreement of their courſes and motions, it ſeems not an improbable ſuppoſition.

There ſeems to have been a particular part of the continent of *North-America*, which has been the *ſeat* of the earthquakes of *New-England*, and to which they have always been confined.

To the ſouth-weſt, they have ſeveral times reached as far as *Maryland*; but never ſo far as *Virginia* or *Carolina*. To the north-eaſt, they have been bounded by *Nova-Scotia*; having never been felt much further than *Halifax*. From the unknown lands, at the north-weſt, they have gone off ſouth-eaſt, into the *Atlantic*: their extent this way, being greater than we are able to trace on either point of the compaſs. The province of *Maſſachuſetts-Bay*, or rather, that part of *New-England* which is about the latitude of 43° north, where the river *Merrimack* empties itſelf into the *Atlantic*, has generally been the centre, or place of their greateſt violence. If from this place, a line be drawn north-weſt, it will pretty well repreſent the central courſe of the earthquakes of this country: and from this line they have extended about four hundred miles to the ſouth-weſt and north-eaſt. It is not meant to be very particular, but only general, as to theſe boundaries.—And the whole country, within theſe limits, has been repeatedly ſhaken,—moſt violently about the middle, and leaſt ſo towards the ſouth-weſt and north-eaſt boundaries. As far as can be gathered from the accounts, it ſeems probable, that moſt of the great ſhocks have reached to much the ſame places: the ſmall ones, indeed, have not had ſuch an extent; being felt only in different provinces and towns. But *all* the earthquakes, within the above-mentioned limits, have come from the ſame point, and ran in the ſame courſe: the great ones reaching to much the ſame extent, as though there was ſomething to direct their motions the ſame way, and to confine them to the ſame limits.

With what *velocity* theſe earthquakes moved, it is not eaſy to determine. In many accounts of earthquakes, their motion has been ſaid to be inſtantaneous, like that of the electrical ſhock. The reverſe has been the caſe in the earthquakes of *New-England.* Inſtead of being inſtantaneous, their motion has never been very ſwift. To compute, indeed, with accuracy, with what velocity any of them moved, we have no ſufficient *data.* Had the times at which any of them begun, been carefully noted at places whoſe diſtances were known, it might have opened the way to ſome very curious concluſions. But all the accounts, excepting one of Profeſſor *Winthrop*, are too general to form any certain inferences of this kind. There is, however, one article in the accounts of the earthquakes of 1727, 1755, 1757 and 1761, from whence we may conclude, that the *velocity* of their motion, was conſiderably leſs than that of *ſound.* Moſt of the accounts of the earthquakes of 1727 and 1755, agree, that the roar was heard at leaſt half a minute before the ſhake began. The ſound, therefore, that was occaſioned by the approach of the earthquake, preceded the ſhock with a motion conſiderably ſwifter than that of the earthquake itſelf. Now, *ſound* moves about thirteen miles in a minute; and the motion of this was conſiderably ſwifter than the motion of the earthquake. In the earthquakes of 1757 and 1761, the ſound was alſo heard half a minute before the ſhock was felt: and as the report was much leſs, and therefore could not reach ſo far as in the larger ſhocks, the inference will be, that theſe ſmall ſhocks moved with a velocity conſiderably leſs than the larger one. And, indeed, the ſuppoſition ſeems not improbable, that the *velocity* with which an earthquake moves, ſhould bear ſome proportion to its *violence*,—to the ſtrength and force of thoſe cauſes, by whoſe operation it is produced. Whether there does not ſeem ſome evidence that this has been the caſe with us, the reader will judge for himſelf, from what has been obſerved above. If this is the caſe, as I believe it is, future obſervations may determine it with much more certainty and preciſion, than any that have yet been made.

But although we are able to diſcern ſome appearances of agreement and ſimilitude in thoſe phenomena that have been mentioned, we cannot diſcern any in the *times* in which theſe earthquakes have happened. From their having all proceeded in the ſame courſe, one might be led to ſuſpect, whether their cauſes, whatever they are, operating in the ſame direction, would not require nearly the ſame intervals of time, to gather ſufficient force to produce the ſame effects. But nothing of this nature is apparent. The intervals of time, at which they have happened, have been very different, and without any apparent regularity. Not to mention the ſmaller ſhocks, there have been five which have been diſtinguiſhed by their being much larger than the reſt: thoſe, I mean, of 1638, 1658, 1663, 1727 and 1755. Between the two former of theſe, there was an interval of twenty-eight years.—Between the two next, an interval of five years: then one of ſixty-four; and between the two laſt, of twenty years. At a medium, this will make one in about twenty-ſeven years. But in theſe different intervals, there is no apparent order, regularity, or proportion, in the times of their happening. Neither does there ſeem to be any proportion between *the intervals of time*, and *the violence of the ſhock*. One would be apt to imagine, that the longer the cauſes were gathering ſtrength, the greater would be the violence of the earthquake when it came: and yet that of 1755 was greater than that of 1727, though the interval of time had not been half ſo long. It is to be obſerved, however, that as our accounts of the earthquakes are but imperfect, as to their number, and much more ſo as to the degree of their violence, all our reaſonings, upon this article, muſt be very uncertain.—Nor could we, without very accurate accounts of the time and violence of the earthquakes, the ſmaller ones as well as the greater, ſtate any proportion between the *times* and the *ſhocks*, ſuppoſing ſuch proportions to exiſt. But if there are any ſuch proportions, or any order and regularity, in their periods, it is not apparent; but rather the contrary, from all the accounts I have been able to collect.

It is alſo worthy of remark, that theſe earthquakes do not ſeem to have any *connection* with any thing that falls under our obſervation. It has been ſuſpected, by thoſe who account for the origin of earthquakes on the principles of electricity, and by many others, that there is ſome connection between the ſtate of the weather, or rather atmoſphere, and the happening of an earthquake. As our knowledge of this ſubject is ſo imperfect, it may not be amiſs to note every thing of this kind. And it is obſervable, that the earthquakes have generally happened in calm, ſerene and pleaſant weather. Some of the accounts are very imperfect in this reſpect: but, in general, they ſeem to agree pretty much in this particular. But though it has generally been the caſe, that the earthquakes have come on in fair and pleaſant weather, it has not been univerſally ſo.—In the earthquake which happened November 22, 1755, after the great ſhock on the 18th, the weather was not clear and fair, but dull, cloudy, and attended with ſmall ſhowers, and a briſk gale at ſouth-weſt.—And in March, 1771, there was a ſmall ſhock, when, inſtead of being fair weather, there was a heavy ſtorm of ſnow. But perhaps it is of no great conſequence to mention this. It has been more common for writers on this ſubject to attempt to find ſome *preceding ſigns*, or forerunners, of theſe events. And in this reſpect, fear and ſuperſtition have been abundantly fruitful. Philoſophy has nothing to do with the many idle reports of this kind, that have prevailed among the vulgar. But among the many things that have been ſuppoſed to exiſt, there is one that deſerves our notice, as having, probably, a real foundation in nature. Ancient and modern writers have ſuppoſed, that it might in ſome caſes be a prelude to an earthquake, when the water, in deep pits, wells, caverns, ſprings, &c. is thrown into uncommon motions, diſturbed, altered and changed, as to its courſe, kind, or quality. It is rational to ſuppoſe, that ſuch events may, in ſome caſes, proceed from thoſe cauſes, which, in a little time, have burſt out, and rent the adjacent country. Some curious obſervations of this kind, were mentioned by Meſſieurs *Dudley* and *Allen*, as happening a few days before the earthquake of 1727: and ſomething of the ſame kind was obſerved previous to the earthquake of 1755. As theſe accounts have been mentioned,* it is unneceſſary to repeat them here. I am far from ſuppoſing, that any certain prediction of earthquakes can be generally made from ſuch obſervations; as ſuch events may, and no doubt do happen, without being followed by any ſhocks; and earthquakes often take place without any ſuch events. But at the ſame time, it can hardly be doubted but that the alterations obſerved in the water of theſe wells, was owing to the operation of the ſame cauſes, that in a few days burſt forth with ſuch violence as to ſhake all *New-England*. With regard to the *ill effects* that have ſucceeded earthquakes in ſome countries, it is well known there have been many and fearful accounts.

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* Vide p. 265 and 277.

In ſome places, they are ſaid to have been followed with great mortality, peſtilential diſorders, and the moſt raging ſickneſs. Nor is it improbable, that the air ſhould be infected with noxious effluvia, from the vapours that were before confined, and perhaps corrupted. It ſeems credible, that ſomething of this nature has been the caſe, and, probably, the *conſequence* of earthquakes, in ſome places. Many of theſe reports, indeed, ſeem to be much like what has been ſaid of the effects of comets, meteors, and the conjunctions of the planets.—But at the ſame time it ſeems probable, both from ancient and modern accounts, that in ſome places, peſtilential diſorders have, in fact, and probably as the conſequence, ſucceeded great earthquakes. Nothing of this nature has been the caſe in *New-England.* It is, however, highly probable, from the Rev. Mr. *Lowel's* obſervation,* that ſome very noxious vapour, or effluvia, attended the eruption of the earthquake of 1727: but no bad effects, no peſtilential diſtempers, no ſweeping ſickneſs, or uncommon diſorder or mortality, has been obſerved to ſucceed any of the earthquakes of this country; no otherwiſe, at leaſt, than what has been common at other times.

CONJECTURES on the CAUSES of theſe EARTHQUAKES.

IN this enquiry into the Cauſes of Earthquakes, it is not my deſign to enter into a particular diſcuſſion of the ſeveral hypotheſes philoſophers have aſſigned, as accounting for the production of ſuch phenomena.—I mean to conſider the ſubject no further than it has relation to the earthquakes of *New England*, and what may be gathered, as to their cauſes, from the preceding HISTORY and REMARKS.

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* Vide p. 268

From the phenomena and obſervations that have been mentioned, we may ſafely infer, that the earthquakes of *New-England* have been produced by *ſomething which has moved along under the ſurface of the earth.* Whatever may have been the caſe in other places, all the earthquakes of this country, ſo far as we have any accounts of them, have been of the ſame kind; conſiſting, not of a ſimple inſtantaneous vibration, like that of an electrical ſhock, but of a gradual heaving, ſwell, or undulation of the earth. This has moved along in much the ſame path, with a motion not very ſwift: and it has reached deep enough below the ſurface of the earth, to affect and diſturb the fountains, ſprings, wells and pits of water. Theſe phenomena, are effects, which would naturally lead us to conclude, that the cauſes, whatever they may be, had their ſeat, riſe and operations under the ſurface of the earth. And this concluſion from the *phenomena*, is ſtrongly confirmed from *obſervation.*—For the ſhocks have come on, roſe to their greateſt height, and gone off, to all appearance and obſervation, as if they had been occaſioned by the rolling of ſome ſolid body under the ſurface of the earth. In this manner Profeſſor *Winthrop* deſcribes that which happened November 22, 1755:— "I was then," ſays he, "ſitting on a brick hearth: and the "ſenſation excited in me, was exactly the ſame as if ſome ſmall "ſolid body, by moving along under the hearth, had raiſed "up the bricks ſucceſſively, which immediately ſettled down "again."* The ſame obſervation has been frequently made

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* Lecture on Earthquakes, p. 12.

by others; and is agreeable to all the accounts that can be collected. And from theſe accounts of the ſeveral phenomena of the earthquakes, and the obſervations that have been made upon them, I think we may lay it down as *a pretty certain fact*, that the earthquakes of *New-England* have been cauſed by ſomething which has moved along under the ſurface of the country.

What thus moved under, and hove up the ſurface of the earth, was probably *a ſtrong elaſtic vapour.* This is inferred from the phenomena that have attended the earthquakes.

Among theſe phenomena, there were ſome that preceded the earthquakes, and looked like a *previous preparation.* In the earthquakes of 1727 and 1755, in particular, it was evident, that the cauſes by which they were produced, were at work ſeveral days before they became ripe for an exploſion. As tho' ſome grand fermentation was taking place in the bowels of the earth, the water, in ſeveral wells and ſprings, was uncommonly altered in its motion, colour, ſmell and quality. This was obſerved three or four days before there was any earthquake. Nothing could better agree with the origin and production of a ſubterraneous elaſtic vapour, than this circumſtance. For however ſuch a vapour be generated, by mixture, fermentation or fire, it would require ſome previous preparation, for its production, or before it would be collected in ſufficient quantities to cauſe an exploſion, or acquire ſufficient force to move and ſhake the ſurface of the earth.

The *noiſe* or *roar*, occaſioned by the earthquakes, has always been ſuch as might have been expected from a ſubterraneous vapour, when fiercely driving along under the ſurface of the earth. What report might be expected from a ſtrong elaſtic vapour, when its motion is confined and directed by a particular channel or paſſage, we may learn from that of a blazing chimney. The action of fire, when turning the inflammable materials, with which the chimney abounds, into flame and vapour, produceth a noiſe or roar of a very particular kind; and which ſeems to be different from almoſt any other: and there is nothing to which the report of our earthquakes is more ſimilar, or has been more often compared.

There is alſo an apparent agreement between the effects of a ſubterraneous vapour, and the *kind* and *motion* of the ſhocks. When the materials, from which a ſubterraneous vapour is produced, lie promiſcuouſly mingled and blended together, the effect of an exploſion would be a violent ebullition, or blaſt upwards; tearing and rending a circle of earth, all around. This ſeems to have been the caſe in the earthquakes of *Sicily*, *Lima* and *Jamaica*. When the vapours can have a regular diſcharge through any aperture in the ſurface of the earth, they will vent themſelves in copious effuſions and exhalations, and thus ſpend their force this way, as they gather ſtrength from time to time. Thus it has been with *Hecla* formerly; and with *Veſuvius*, *Ætna*, and other volcanoes now. But when the vapours are confined under the ſurface of the earth, and have ſubterraneous paſſages, or proper ſtrata, for them to run in, by the violence of their expanſion, they will heave up the ſurface of the earth, and thus cauſe, not an inſtantaneous concuſſion, but a progreſſive ſwell or undulation of the earth.—And this will be continued till the vapours, thus confined, find or force for themſelves a paſſage, where they may burſt from their caverns, and diſcharge themſelves into the open air.—

And theſe are phenomena in all reſpects agreeing with thoſe that have attended the earthquakes of this country.

The ſtrength and force of ſuch a vapour, would be ſufficient to account for the *violence* of any ſhocks we have had. A very great force muſt be requiſite to heave up, and cauſe a progreſſive ſwell in the ſurface of the earth, and this, perhaps, from ſome depth below.—And with what force ſubterraneous vapours may be attended, we may form ſome idea from their effects. In thoſe which have ſhook *Veſuvius* and *Ætna*, it has been no uncommon thing to ſee them throw up at once, ſuch clouds of ſand, aſhes and pumice-ſtones, as are capable of darkening the whole air, and covering the neighbouring country with a ſhower of duſt, &c. to many miles diſtance. Great ſtones, alſo, of ſome tons weight, are often thrown to the diſtance of two or three miles, by ſuch exploſions. Monſ. *Bouguer* tells us, that " he met with ſtones in *South-America*, of eight or nine feet diameter, that had been thrown from the volcano *Catopaxi*, by one of theſe blaſts, to the diſtance of more than three leagues." In *Ulloa's* account, the whole plain, near *Latacunga*, is ſaid to be full of pieces of rocks, ſome of which were thrown, from the ſame volcano, to the diſtance of five leagues.† If ſubterraneous vapours, when they have had nothing to confine them, have acted with ſuch force, we may eaſily conceive that they muſt heave up, and cauſe a progreſſive ſwell in the ſurface of the earth, when their force was confined, and their motion directed by a particular paſſage.

The *eruptions* and *effuſions* that have attended our earthquakes, have alſo borne ſtrong marks of ſubterraneous vapour. That a vapour of ſufficient force to ſhake and move the ſurface of a whole country, ſhould break out in many places, where it came near to the ſurface of the earth, is agreeable to the preſumption of theory. Thus it has been with ſeveral of our earthquakes. In that of 1727, there was an eruption at *Newbury*, attended with an effuſion of ſand, containing ſmall mixtures of ſulphur, and a very noxious, ill-ſcented vapour. Strong ſulphureous ſmells were obſerved in other places; and, as ſome ſuppoſed, there were alſo appearances of flame. In the earthquake of 1755, there were eruptions at *Scituate*, *Pembroke*, *Lancaſter*, &c. with large effuſions of ſand, probably of a ſulphureous nature. Whether this was the caſe with any of the other earthquakes, the accounts are not particular enough to determine. But in theſe, both the matter and ſmell attending the eruptions, afforded ſtrong marks and evidence of ſubterraneous vapours.

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† Phil. Tranſ. for 1760, p. 592.

The earthquakes of *New-England* have alſo made ſuch *alterations* in the bowels, and upon the ſurface of the earth, as a ſtrong ſubterraneous vapour would produce. Very conſiderable alterations might be expected in the bowels, and upon the ſurface of the earth, and in the ſyſtem of ſprings, fountains, currents and ſtreams of water, from a vapour of ſuch force as to break thro' the ſurface of the earth, and of ſuch extent as to reach from one country to another. Such effects have always followed the larger ſhocks. In that of 1663, incredible alterations are ſaid to have been made in the ſurface of the earth at *Canada*, for many leagues through the country. Rocks and mountains were, in ſome places, thrown down, and conſiderably removed; and the channel in ſome parts of the river *St. Lawrence*, was very much changed and altered. In thoſe of 1727 and 1755, the ſurface of the earth, in ſome parts of *New-England*, was conſiderably broken and changed; and the whole ſyſtem of fountains and ſprings, was greatly affected. Great alterations were made in wells, ponds, fountains and currents of water: ſome were dried up, others opened; new ones produced, and, in many, the kind, quality and quantity of the water was greatly changed.—Alterations in all reſpects ſimilar to what might be expected from ſubterraneous vapours, fiercely driving along under the ſurface of the earth, with a force ſufficient to move and ſhake ſo large a part of its ſurface.

This opinion agrees alſo *with the effects which the earthquakes have had on the water.* The earthquakes of *New-England* have been felt not only upon the land, but alſo upon the ſea. Several veſſels, which have been upon the coaſts at the times of the larger ſhocks, have been very ſenſibly affected. To the people on board, the ſhocks ſeemed as if the veſſel had ſtruck upon a rock; or rather, as if ſomething had thumped againſt their bottoms. This, it is probable, was the very caſe; and is agreeable to what might be expected from the operation of ſubterraneous vapours.

The earthquakes moved with a velocity ſufficient to communicate the ſame kind of motion to the water that they did to the earth; and thus cauſed a very deep, large and extenſive ſwell or wave. This wave, ariſing from the bottom, rolled along with much the ſame velocity as the earthquake moved: the effect of which, when it came to a veſſel floating upon the water, would be a very conſiderable ſtroke or thump againſt the bottom,—more or leſs violent, according to the violence of the ſhock, and the depth of the water.—And in this manner have veſſels, upon the coaſt, been affected;—ſome ſcarce perceiving it; others not at all; while to others it was pretty violent.

There have been other effects upon the water, ſuch as a ſurpriſing flux and and reflux of the ſea,—extraordinary agitations and commotions of the waters,—an uncommon deſtruction of fiſh, &c. Theſe effects have not been common, and never but at a conſiderable diſtance from the coaſt of *New-England.* And they ſeem to be plain and evident marks and effects, of the diſcharge of the ſubterraneous vapours, at the bottom of the ſea. Such a diſcharge, when ſmall, would be ſufficient to occaſion the deſtruction of ſuch fiſh as were near it : and when large, would put an end to the earthquake, and produce the moſt extraordinary agitations and commotions of the ſea, by a furious eruption of vapours at its bottom ; which would immediately force their way through, or carry up before them, the whole body of water that lay over them.

And thus as to the *concluſion* :—It might be naturally expected, that as the vapours, by which the earthquakes were cauſed, were ſome time in growing ripe, fermenting, or in a ſtate of previous preparation, they would not be wholly ſpent or diſcharged at once, but leave ſmall remainders at particular places. Thus it has proved in all the great earthquakes we have had. The vapours, by which they have been produced, have not been wholly ſpent at the firſt ſhock : but what has remained, and what has gathered after a great exploſion, has produced various ſmall ſhocks in ſeveral places, for ſome time after the great ones :—thus waſting and evaporating by little and little, as they were collected and prepared at firſt ; till, by degrees, all has become quiet again.

Such have been the phenomena that have attended the earthquakes of *New-England.*—And to me, they appear to be ſuch, as (viewed either together or apart) make it highly probable, that what moved under, and hove up the ſurface of the earth, was *a ſtrong elaſtic vapour.**

The *origin* or *production* of ſuch a vapour, may be accounted for from the CONTENTS of the earth. Much the largeſt part of the contents of the earth, will always remain hidden from our view, and beyond the reach of our knowledge. We have, however, penetrated far enough below its ſurface to find, that many of the bodies it contains, are of ſuch a texture, or contain particles of ſuch a nature, as to generate, or be eaſily turned into vapour. This is the caſe with coals, ſalts, ſulphur, nitre, air, water, moſt kind of minerals, and all ſubſtances which contain oily particles. Such bodies, at leaſt ſome of the particles they contain, are eaſily and often turned into a very ſtrong, ſubtle, elaſtic vapour. With ſome, nothing more is neceſſary to generate a very powerful vapour, than a bare *mixture* of different bodies. Thus equal quantities of powdered ſulphur and iron filings, being mixed with water, ſoon become too hot to be touched; and in a little time emit flame and vapour. And if iron, oil of vitriol, and water, become mixed together, there will inſtantly ariſe a violent ebullition, with fumes copiouſly exhaling; and which are ſo very inflammable, that if ſet on fire, they go off at once with a loud exploſion. The ſame is alſo effected by *fermentation.* Inſtances of very ſtrong elaſtic vapours, produced this way, are ſo common and obvious, that particular caſes need not be mentioned. All ſeparable, mixt and compound bodies, may be the ſubject of this operation: and the eaſier they are ſeparable, whether by means of water, air, or heat, the more readily they ferment.—And when they do ferment, they will produce a vapour more or leſs ſtrong, according to the quantities of the fermenting matter, and the degree of the fermentation. But in no method is a more powerful vapour produced, than by *fire*. What an amazing effect will a ſmall ſpark of this have on nitre and ſulphur, when made up into ſuch a compoſition as that of gun-powder! How ſmall a quantity of this powder, when on fire, will generate a vapour of ſufficient force to burſt the firmeſt rocks! Air, by the application of fire, becomes ſo elaſtic, as to break through all oppoſition.—And there are many effects produced by the vapour of water, when intenſely heated, which make it probable, that the force of gun-powder is not near equal to it. And, in general, all combuſtible bodies are capable of being turned into vapour, by the action of fire.—And fire ſeems to be a fluid, which is ſpread through almoſt all bodies whatſoever. It certainly exiſts, in very large quantities, in the bowels of the earth.—Some parts, as the volcanoes are actually burning, and have been throwing out fire, flame, ſmoke, cinder, rocks and lava, for many ages.—And where there are no ſuch appearances of it, it exiſts, and is diffuſed in great quantities. That this is the caſe is evident from hot ſprings,—the warmth that is always found in deep mines and pits,—and thoſe burning mountains that have been thrown up from the bottom of the ſea.—And when collected into large quantities, its effects on water, air, the fumes of fermenting minerals, and all kinds of combuſtible bodies, would be to generate a vapour more or leſs ſtrong, according to the quantities of the minerals of which it was compoſed.

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* From the phenomena which have been mentioned, it ſeems probable, that this elaſtic vapour was a fluid, of the ſame nature as that which is now called *inflammable air.*

Thus, in the *contents* of the earth, we find ſufficient materials for the production of the moſt ſtrong, active and powerful vapour;—and ſuch materials as do, in fact, produce moſt terrible volcanoes,—vapours that have hove up, and broke thro' the ſurface of the earth,—and earthquakes that have ſhaken the whole country, for twenty miles around *Veſuvius* and *Ætna.* —And ſuch exploſions and concuſſions are what all thoſe countries are ſubject to, which abound with ſulphur, nitre, and ſuch combuſtible materials.

As the *contents* of the earth will account for the *origin*, the *ſtructure* of it will account for the *motion* and *direction* of a ſubterraneous vapour. Were the globe a perfect ſolid, there could be no motion of a ſubterraneous vapour under its ſurface. But this is not the caſe.—Inſtead of being a perfect ſolid, the earth is of a *cavernous ſtructure*; containing various pits, holes and caverns. Some of theſe are dry; others are the fountains, or contain currents of water; and others abound with the fumes of fermenting minerals, and with various kinds of vapour and effluvia. That the earth is thus of a cavernous ſtructure, is evident from the mines, ſprings, and currents of water, that are found below its ſurface, in every country, and in almoſt every place. And it is probable, that many of theſe ſubterraneous caverns may be of a great extent;—ſome running in a direct, and others in long, crooked, unequal paſſages. —And by thus winding, meeting, croſſing and mixing with each other, they may form communications between very diſtant parts of the earth. The *manner* in which the ſolid and fluid parts of the earth are *diſpoſed*, is alſo worthy of remark.—In ſome places, they are found promiſcuouſly mingled and blended together, in a manner which has no apparent order or regularity. In other places, the various kinds of *ſolids* appear to be diſpoſed with the utmoſt apparent regularity, in the form of different and diſtinct *ſtrata* of clay, coals, ſalts, ſulphur, minerals, &c. It is thus alſo with the *fluids* ;—in many places, they are regularly collected into quantities, or fountains, within the bowels of the earth ; in others, they are conſtantly and regularly moving in perpetual ſtreams and currents : ſome of which are charged with ſulphureous particles ; others with thoſe of iron ; and others, with various other tinctures and mixtures.

And from this *Structure* of the earth, *the motion* of a ſubterraneous vapour would receive *its direction.* For vapours, generated and increaſing in the bowels of the earth, if they found no vent upwards, muſt naturally take their courſe and ruſh fiercely along under the ſurface of the earth, according as they found ſubterraneous *paſſages* or *ſtrata*, of proper materials to conduct them.—And it ſeems as if ſomething of this nature muſt be the caſe in this part of *America*. That there ſhould be a particular part of the country, as to width, to which the earthquakes of *New-England* have repeatedly reached ; that they ſhould all be of the ſame kind,—come from the ſame point,—and proceed in the ſame path ;—theſe phenomena cannot be ſuppoſed to be the effect of what is called chance or accident. It is evident there muſt have been ſomething which ſerved as *conductors.* If *ſubterraneous paſſages*, of ſuch extent as theſe earthquakes, ſhould be admitted, it would be difficult to account for the width of the earthquakes, on that hypotheſis. The more probable ſuppoſition ſeems to be, that there are ſome particular *ſtrata*, which have ſerved as fuel or conductors to the vapour. And that this was the caſe, ſeems further probable from the ſulphureous mixtures that have been thrown out at the different eruptions. Inſtances of theſe eruptions are mentioned in the accounts of the earthquakes of 1727 and 1755.—And they are ſuch as make it probable, that there is ſome particular *ſtratum* under the ſurface of the country, which has ſerved and will ſerve to direct the motion of the ſubterraneous vapour, from the places of its origin, to that of its grand final eruption.*

On this account of the Cauſes of the Earthquakes of *New-England*, it may not be amiſs to remark, that part of it ſeems to be matter of *fact*, and part matter of *conjecture*. As the cauſes lie out of ſight, and beyond the reach of obſervation, we have no way to come to the knowledge of them, but by general reaſonings from the phenomena that fall under our obſervation. Theſe phenomena, I may venture to ſay, have been fairly related:—but whether the inferences that have been drawn from them, are juſt,—the conjectures, ſuch as are probable,—the concluſions, well ſupported,—and the evidence, ſuch as might have been expected,—theſe are ſubmitted to the judgment of others. Hypotheſes may be of uſe to put us upon further enquiry, and a more critical examination; but are never to be received, any further than they are ſupported by proper evidence.

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* Such *ſtrata* are not at all uncommon. Many countries are known to abound with, and to be diſtinguiſhed by them. "We have an inſtance of it in the chalky and flinty countries of *England* and *France*, which (excepting the interruption of the channel, and the clays, ſands, &c. of a few counties) compoſe a tract of about three hundred miles each way." Phil. Tranſ. for 1760, p. 587. The volcanoes in the *Andes*, are in all probability derived from the ſame *ſtratum* of combuſtible minerals; the extent of which cannot be leſs than five thouſand miles,—for ſo far do the mountains and volcanoes extend.—And thus in *North-America*, if we may give credit to *L. Evans*, in deſcending from the mountains which adjoin to the weſtern lakes, the ſame ſets of *ſtrata*, and in the ſame order, are generally kept up.

In ſome countries, earthquakes have ceaſed upon the breaking out of volcanoes. If there were volcanoes in this part of *America*, which might ſerve to interrupt the *ſtratum*, and as a vent for the ſubterraneous vapours to diſcharge themſelves, it is probable the earthquakes of *New-England* would not run in ſuch a regular manner, through ſuch an extent of the country.

GENERAL REFLECTIONS on EARTHQUAKES.

THE preceding ACCOUNTS, OBSERVATIONS and CONJECTURES, have been confined to the earthquakes of *New-England.*—But they will naturally lead us to ſome GENERAL REFLECTIONS on the nature, uſe and effects of theſe formidable phenomena. Thus,

If we are right in our conjectures on the cauſes of earthquakes, we may conclude, that the globe always has been, and will be ſubject to ſuch concuſſions. From the earlieſt ages, of which we have any accounts, this has been the caſe. Many parts of the earth bear the marks of great and furious eruptions; not a few of which, were prior to all hiſtorical monuments and records. The eruptions of the noted *Ætna,* may be traced back an hundred years before the ſiege of *Troy.** *Veſuvius* was a volcano before the foundations of *Herculaneum* and *Pompëü* were firſt laid. Theſe cities were covered by an eruption of *Veſuvius,* A. D. 79. Their foundations and pavements are all of that melted and vitrified ſubſtance called *lava,* which *Veſuvius* had thrown out;—which is a proof of great eruptions, prior to the foundations of theſe cities.† How long theſe volcanoes, or thoſe in *Iceland,* the *Eaſt-Indian* iſlands, and *South-America*, have been burning, we have no hiſtory or tradition ancient enough to inform us. Many of their effects bear the marks of more furious eruptions than any there have been in modern times. The ſoil for more than twenty miles, round *Naples*, by its cinder, ſtones, burnt matter and lava, appears to have been the production of very ancient ſubterraneous fires, earthquakes and eruptions.* The *Appenines*, a chain of mountains which divide the continent of *Italy* from north to ſouth, and extend even to *Sicily*, diſcover many tokens of an internal fire; and were judged, by that celebrated philoſopher, M. de la *Condemine*, to be a chain of ancient volcanoes. This is alſo the caſe with that long chain of mountains in *South-America*, known by the name of the *Andes*. Theſe mountains run from 45° ſouth latitude, to ſeveral degrees north of the line, and alſo throughout all *Mexico*; being, according to Monſ. *Bouguer's* account, five thouſand miles in extent. The ſeries of volcanoes, formed by theſe mountains, is interrupted: many are totally extinguiſhed; and there are many which are ſtill burning; and many of the ancient ones frequently burſt out again.‡ Several of the *Weſt-Indian* iſlands, the *Azores*, *Teneriffe*, and moſt high mountains, either contain volcanoes, or, by the veſtiges of calcination and vitrification, ſhow the former effects of them.—And as ſeveral iſlands and mountains have been ſunk, ſo we have authentic accounts of ſeveral that have been thrown up from the bottom of the ſea, by ſubterraneous fires. Such effects with the relations of hiſtory, afford plentiful evidence, that the globe has always been ſubject to and greatly affected by ſubterraneous fires, earthquakes and volcanoes.

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* According to M. *D'Orville.*

† Phil. Tranſ, for 1771. Art. 1.

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* Phil. Tranſ. for 1771. Art. 1.

‡ *Condamine's* Travels into *Italy*.

The ſame cauſes which have produced ſuch effects on the ſurface, are undoubtedly ſtill exiſtent in the bowels of the earth. Proper periods of time may be requiſite for them to grow ripe, or gather ſtrength ſufficient to cauſe an exploſion or earthquake. But as the materials from which ſubterraneous vapours are formed, conſtantly exiſt in the bowels of the earth, they will be as conſtantly fermenting; and thus increaſing the quantity and force of the vapours, till they ſhall become ſufficient to break through all oppoſition, and force for themſelves a paſſage thro' the earth. And although they may in ſuch ways be diſcharged from time to time; yet, ſo long as the ſame powers ſhall ſubſiſt in matter, new vapours will be produced; and, of conſequence, the ſame effects, after proper intervals of time, will again take place. Nor are they to be viewed as marks of any diſorder or irregularity in the works of nature. For,

Notwithſtanding all their terrible effects, earthquakes ſeem to be a neceſſary conſequence of ſuch laws of nature, and powers in matter, as are, upon the whole, greatly beneficial to the globe. There is no phenomena in the whole courſe of nature, ſo formidable as that of an earthquake.—Nor is there any that has ſpread more univerſal horror, calamity and deſolation. Hiſtory, ancient and modern, abounds with accounts of large countries that have been ſhaken,—whole cities that have been ſunk and covered,—and immenſe numbers of mankind that have been deſtroyed, by theſe dreadful convulſions of nature. In the earthquake which ſhook *Sicily*, in the year 1693, fifty-four cities and towns, with an incredible number of villages, were either deſtroyed or greatly damaged, and about ſixty thouſand perſons periſhed. In that at *Jamaica*, in 1692, almoſt the whole of *Port-Royal* was ſwallowed up, and large numbers of its inhabitants buried in its ruins.—And in the earthquake at *Lima* in *Peru*, in 1746, all the buildings in that city, and in the port of *Callao*, except about thirty, were ſunk, or laid in ruins, and great numbers of people deſtroyed :—four hundred and fifty-one ſhocks, many of which were equal to the firſt, ſucceeding in the ſpace of four months. The deſtruction of *Liſbon*, by the earthquakes in 1755, was alſo attended with the moſt tragical ſcenes of deſolation, death and miſery. And yet, notwithſtanding all theſe dire effects of earthquakes, it is very poſſible, that the laws and cauſes from whence they ariſe, may be a neceſſary proviſion, and a real advantage to the globe. The power of gravity, the wind and water, rain, heat and cold, have occaſioned the deſtruction of vaſt numbers of mankind : and yet they are a general advantage to the earth, and to its inhabitants ;—and ſuch an advantage, that no creature could live on this globe without them. And ſince they produce an *over-balance* of good, they are to be eſteemed advantageous and beneficial upon the whole ; although in ſome particular caſes, they may be attended with very dangerous and fatal effects. This, it is probable, is the caſe with all the laws, powers and operations of nature ; and to all thoſe agitations and concuſſions to which the earth is ſubject.

To enumerate all the ends to which theſe formidable phenomena may ſerve in the natural world, would require higher degrees of knowledge than it is probable we ſhall ever have of this ſubject. And yet, perhaps, we may ſee enough to convince us of the wiſdom and benevolence of the Creator, in making the globe ſubject to ſuch concuſſions. Theſe extenſive and powerful agitations tend to weaken the attraction, looſen the parts, and open the pores of the earth ; and thus to fit and prepare it for the purpoſes of vegetation, and for the various kinds of produce that are neceſſary for the ſupport of animal life. Were an inſuperable bond of attraction to take place on the ſurface, or in the bowels of the earth, without ſomething to oppoſe its power,—fluidity, motion, vegetation, and all nature would be at a ſtand. The power of gravity tends to this: And hence we find it neceſſary, by the operations of agriculture, to break the ſurface of the earth, to looſen its parts, and open its pores, and thus weaken its attraction, that it may be fit for the production of ſuch fruit and grain as we want in the courſe of the year. An earthquake performs that in the bowels of the earth, which the various methods of agriculture perform on its ſurface.—And it is probable, that the former is equally neceſſary to the purpoſes of vegetation, as the latter.—And what ſeems to confirm theſe conjectures, it is obſervable, that thoſe places which are moſt ſubject to earthquakes, are the moſt noted, *cæteris paribus*, for the fruitfulneſs of its ſoil, and the plenty of its produce. Thus *Italy*, *Peru*, *Manilla*, and eſpecially *Ætna* and *Veſuvius*, places greatly ſubject to earthquakes, are celebrated for an uncommon fertility. There are other important ends which may be anſwered by earthquakes. Thoſe ſubterraneous vapours, by which they are cauſed, ſeem neceſſary to prevent the inward parts of the earth from becoming too denſe, compact and hard, in conſequence of their attraction.—And when theſe vapours are collected in large quantities, it may be neceſſary to have them diſcharged into the atmoſphere, to prevent a diſſolution of the globe through the force of their elaſticity or repulſion. It may alſo be neceſſary to have new ſubterraneous paſſages opened,—old ones diverted from their former courſes,—and new communications eſtabliſhed between different countries,—that all parts of the earth may be ſupplied with ſuch kinds and quantities of water and air, as the growth of bodies, in the bowels and upon the ſurface of the earth, may require; and that the ſolid and fluid parts of the earth may be kept in their due place, connection and order.—And, in general, we may preſume, from the analogy of nature, that there may be, and no doubt are, many ends and uſes to which ſubterraneous fires and earthquakes may ſerve, of which we have as yet no ideas or conjectures. But however theſe things may be,

It is probable, that our knowledge of this ſubject will increaſe, as all other branches of natural knowledge have done, and by the ſame means, obſervation and reaſoning. In the contents and ſtructure of the globe, the Creator of it ſeems to have made proviſion for the production of ſubterraneous vapours and exploſions. Earthquakes may of conſequence be expected, at proper intervals of time, in every country and climate, ſo long as the earth ſhall continue to exiſt in its preſent form. As theſe events happen, poſterity will have opportunity to examine their phenemena, to note their effects and operations, and to mark all their differences and agreements: and, of conſequence, they will be obtaining more and more inſight into their nature, cauſes and effects. The methods of reaſoning which are now happily introduced into philoſophical ſubjects, though their effects may be ſlow, are yet certain and progreſſive. Every age will be doing ſomething for the next.—And the ſeveral philoſophical ſocieties already eſtabliſhed, by collecting and recording obſervations, are, and will be, providing materials for the ages that are to come.—And when a ſufficient number of obſervations ſhall be thus collected, inferences may be drawn, and concluſions may be formed from them, of which, as yet, we have not the leaſt thought or ſuſpicion. It has been thus in all other branches of philoſophy : and the ſame accuracy of obſervation and reaſoning, when applied to the philoſophy of earthquakes, will probably bring to light things, of which we have now no knowledge or conception.

From any knowledge we yet have of the nature and cauſes of earthquakes, nothing would appear more romantic, than to attempt to predict when ſuch formidable concuſſions will happen. We know ſo little of their cauſes, much leſs when theſe cauſes will have collected ſufficient force to burſt forth and ſhake the adjacent country, that we have no way to form any rational concluſions as to the time when an earthquake will happen, from any inferences founded on the knowledge of the nature and operations of their cauſes. Nor can we receive much, if any, help from any *preceding ſigns* :—I do not mean thoſe which fear and ſuperſtition have formed ; but from any regularity of their periods,—ſtate of the atmoſphere,—uncommon motion of wells, ſprings, and the like.—For if there is any connection between things of ſuch a nature, and the happening of an earthquake, it is what we do not underſtand.

But our ignorance of theſe things ought not to be made an argument, that there is not in reality any regularity or order in theſe events ; or that it will always be impoſſible to diſcover ſo much of the nature and operations of natural cauſes, as to diſcern the ſame ſimplicity, order and harmony, in the ſeveral phenomena of earthquakes, as are apparent in many other works and operations of nature. In all thoſe works of nature, of which we have any tolerable conceptions, ſtated laws, and a ſteady regard to them, have been obſerved.—And this has been manifeſt and apparent in the ſame degree as our knowledge of any ſubject has been advanced. There was a time when univerſal confuſion and diſorder were ſuppoſed to prevail in the courſes, motions and appearances of the heavenly bodies. But as the knowledge of the true aſtronomy increaſed, the moſt perfect order, harmony and proportion has been diſcovered in the motion and appearance of every ſtar, planet and comet.—And it is now well known, that all the ſuppoſed irregularity in any of theſe bodies, was nothing more than want of knowledge, and confuſion of ideas in the obſerver. If we may reaſon from analogy, the concluſion will be, that it is the ſame in all other caſes. It can hardly be doubted, therefore, but that there is the ſame harmony, rule and order,—the ſame general and ſtated laws, in the cauſes and operations of earthquakes, as there are in all other events of nature. No reaſon can be aſſigned why theſe alone, of all the works of GOD, ſhould be made up of irregularity and confuſion. It muſt, therefore, be ſuppoſed, that earthquakes (like all other events that depend on natural cauſes) are ſubject to certain and determinate laws and rules, which are in themſelves conſtant, regular and harmonious,—whether theſe laws, or this regularity, is known to us or not.

The ancient *Egyptians* and *Chaldeans*, by a long courſe of obſervations, are ſaid to have been able to foretell the appearance of comets, and the approach of earthquakes.* The greateſt philoſophers have ſuppoſed their predictions of this kind were founded not on any knowledge they had of the laws and powers of nature, but on the vain arts of judicial aſtrology. This might be the caſe.—It is, however, to be wiſhed, that we could be a little more certain what knowledge the *Egyptians* pretended to in this matter. It is well known, that the ſciences were much cultivated among that diſcreet people. Geometry and aſtronomy, if they were not begun, received very great improvements from them. The *Greeks* had all their aſtronomical learning from *Egypt*. *Pythagoras* got the knowledge of the true ſyſtem of the univerſe from the *Egyptian* prieſts.—And their advances in ſeveral parts of the mathematics, were great and uncommon. How far they were acquainted with the aſtronomy of comets, I am not able to ſay. Some of the *Chaldeans*, and *Pythogorian philoſophers*, taught many things as to the nature, orbits and revolutions of comets; which, though long diſregarded, modern aſtronomy has adapted, and abundantly confirmed.* And that there was nothing impoſſible,—nothing romantic, in attempting to predict their appearance, the great *Halley* has fully demonſtrated. And whether they might not have ſome knowledge as to the philoſophy of earthquakes, which, thro' the ignorance and barbarouſneſs of after ages, might be loſt to the world, ſeems worthy of enquiry.

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* *Diod. Siculus.*

But however this may have been, it is at leaſt poſſible, that regularity, order and laws may be diſcovered in theſe, as well as in other works of nature. It is, indeed, but very little that is yet known of the nature, cauſes and operations of theſe events. It will, probably, require the obſervations of many ages to digeſt and form them into a proper ſyſtem.—And a long courſe of obſervations may open new ſcenes to poſterity, and enable them to form concluſions,—I had almoſt ſaid *predictions*,—which to us would appear wild, abſurd and ridiculous. To me there appears as much ground for ſuch a conjecture, as *Se-*

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* *Gregory's* Aſtronomy. Book v. ſect. 1.

neca had ſeventeen hundred years ago for his, relative to comets; but which has literally been fulfilled.* But leaving theſe things to the ages that are to come,—

From contemplating theſe mighty works of nature, a philoſophic mind will naturally riſe in admiration and reverence, to the FRST GREAT CAUSE OF ALL! In all the works of nature, we find plain marks of that wiſdom, power and goodneſs, with which the whole plan, frame and conſtitution of it, was firſt formed and adjuſted. As all natural effects take place in conſequence of cauſes and laws derived at firſt from GOD, true philoſophy agrees with the holy ſcriptures, in aſcribing all ſuch events to his agency. It was no doubt with a view *ultimately* to *moral* purpoſes, that the laws of nature were firſt eſtabliſhed: and nothing can be better adapted than many of their operations, to awaken and direct the attention of mankind to the ſupreme Governor of the world. By the operation of natural cauſes, the Deity often 'ariſeth to ſhake terribly the 'earth.' 'He looketh on the earth, and it trembleth: he 'toucheth the hills, and they ſmoke.' 'He removeth the 'mountains, and overturneth them in his anger.' 'The pil- 'lars of heaven tremble, and are aſtoniſhed at his reproof.'

Amidſt ſuch convulſions of nature, ſtrong impreſſions of the power and majeſty of GOD, will naturally take poſſeſſion of the human mind. Mankind will ſee and feel their dependence upon their Creator,—with the wiſdom, benefit and advantage of ſuch a ſteady courſe of virtue, as leads to an habitual truſt in his providence and protection. Such unuſual and great events will powerfully awaken their attention to *morals*, and thus promote the advantage, although it may occaſion loſs and terror to mankind.

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* 'A time,' ſaid this excellent philoſopher, 'will come, when thoſe things 'which now lie hid, will at laſt be brought to light, by length of time and the 'diligence of poſterity: for it is not one age that is ſufficient to make ſuch great 'diſcoveries.' *Seneca*, Nat. Queſt. lib. vii. chap. 25. May we not venture to ſay the ſame of earthquakes?

To pretend to be above fear, or to attempt to be unmoved with ſuch concuſſions of nature, would argue, on the one hand, a folly or a pride unworthy a philoſophic mind: and on the other, to give way at every ſuch event, to ſuch confuſion of thoughts and paſſions, as leaves no command over the mind, is a weakneſs as much as poſſible to be avoided. Of this we may at all times be certain,—the preſent frame of nature will ſubſiſt ſo long as Infinite Wiſdom and Goodneſs ſee it to be fit.—And no event will ever take place in the natural world, which was not foreſeen by him who is the AUTHOR OF NATURE, and deſigned to anſwer ſome wiſe and benevolent purpoſe. Of his favour mortals may be ſure, ſo long as they maintain a ſteady regard to the rules of virtue. This will always be productive of ſafety and happineſs; though the immediate effect of the preſent convulſions of nature, will probably be as the poet ſays,

> *Terra tremit: fugêre feræ, et mortalia corda*
> *Per gentes humilis ſtravit pavor.*

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